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IVAN L. SANDER heads the Central States Station's research at the Mead Experimental Forest near Chillicothe, Ohio. Here the Station and the Mead Pulp and Paper Company are studying how to manage hardwoods for pulpwood. Beginning his Forest Service career at the Columbia, Missouri, field office on the oak wilt project in 1953, Sander transferred in 1955 to the Berea, Kentucky, field office where he specialized in forest management and silviculture. His Mead Forest duties began in 1961 and are carried out from the Athens, Ohio, field office. He is a graduate of the University of Missouri, receiving bachelor's and master's degrees in forestry there in 1952 and 1953.

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Bulldoze or Disk to Regenerate Shortleaf Pine in Kentucky

Ivan L. Sander

Mature shortleaf pine (*Pinus echinata* Mill.) or oak-pine stands cover many of the broad ridgetops of the Cumberland Plateau in eastern Kentucky. A dense understory of tolerant hardwoods in these stands generally prevents shortleaf pine from regenerating satisfactorily following cutting (fig. 1).

A study begun in 1956 shows that bulldozing and, to a lesser extent, disking after logging aid in establishing shortleaf pine regeneration. Four years later, more shortleaf pine seedlings are free to grow, competing hardwoods are fewer, and ground cover is less on treated plots than on those given no site preparation.

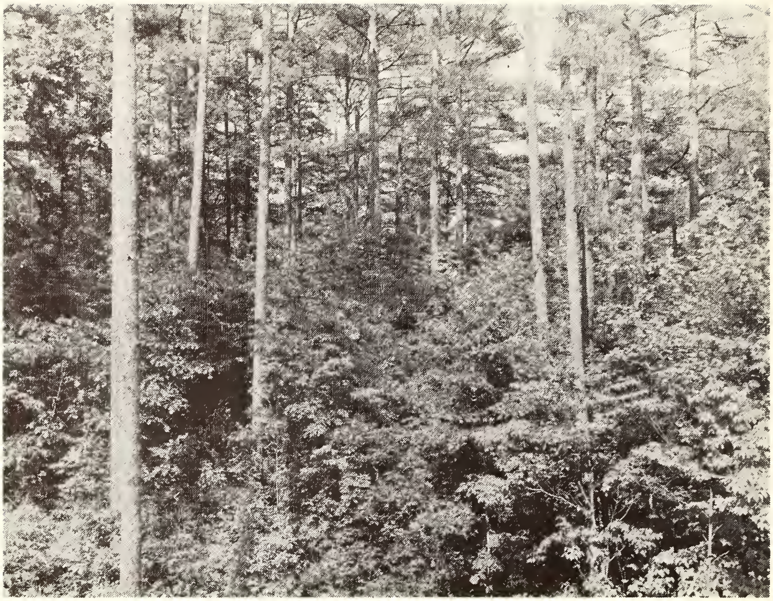

FIGURE 1. — Dense hardwood understory under mature oak-pine stands.

What We Did

The study was made on eight 2¼-acre plots located in mature oak-pine stands of site index 60.[1] A harvest cutting was made leaving 15 seed trees per acre on four of the plots and 6 seed trees per acre on the other four plots. The best seed trees available, based on size and evidence of past seed production, were left as evenly distributed as possible over the plots.

Each plot was divided into three subplots. Site preparation was carried out to destroy or reduce the hardwood understory and expose mineral soil. Bulldozing after logging and disking after logging were compared to logging only, used as a check.

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[1] Height of dominant shortleaf pine at 50 years of age.

Bulldozing uprooted or sheared off the hardwood stems at ground level, removed the litter, and exposed mineral soil on 84 percent of the plot area (fig. 2). The rest of the area was missed in maneuvering around seed trees and large stumps. An effort was made to move as little topsoil as possible, although some of course was dislodged.

In contrast, disking with a heavy tractor-drawn disk, though it cut off many of the smaller hardwood stems, only partially uprooted larger ones. It turned up mineral soil mixed with leaf litter on only 61 percent of the plot area (fig. 3). Besides missing areas in maneuvering around seed trees and stumps, the disk rode over accumulated slash that would have been pushed away by the bulldozer.

In logging only, used as a check, horses were used to ground skid logs along brushed-out skid trails. This exposed mineral soil on only 14 percent of the plot area, all of which was along these trails and on log landings. Practically none of the hardwood understory was destroyed in this operation (fig. 4).

Ten permanent, randomly located, milacre quadrats in each subplot were used to inventory the reproduction in the fall of 1957, 1958, and 1960.

In 1959, 3 years after treatment, the vegetation other than the pine on each plot was surveyed. Aside from the seed trees, the vegetation was divided into three layers: a ground layer consisting of all grasses, herbs, and low shrubs less than 3 feet tall; a high-shrub layer including all hardwood stems and shrubs 3 to 6 feet tall; and an understory layer of all hardwood stems more than 6 feet tall. The percent of the ground covered by these layers was estimated for each treatment. At the same time a complete survey of the ground layer was made by the Braun-Blanquet system.[2]

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[2] Phillips, Edwin A. Methods of vegetation study. 107 pp., illus. New York: Henry Holt & Co., Inc. 1959.

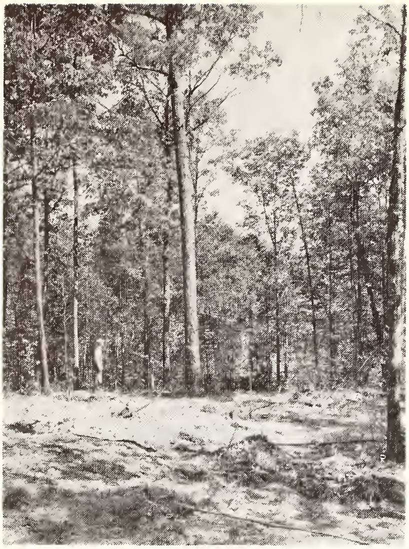


FIGURE 2.—(Left) Bulldozed plot after treatment. Note uniform coverage of the area, removal of hardwood brush, and the large amount of mineral soil exposed.

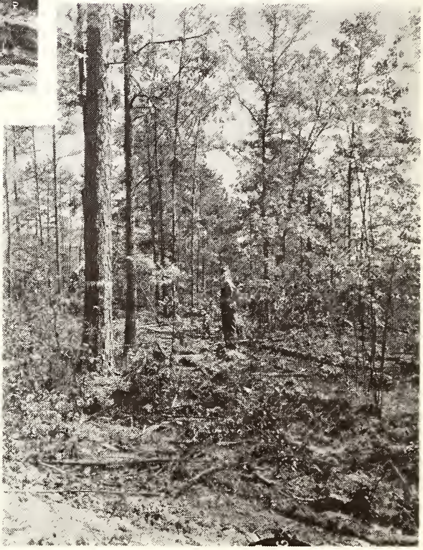


FIGURE 3. — (Right) Disked plot after treatment. Note presence of slash and debris on ground and some hardwoods left.

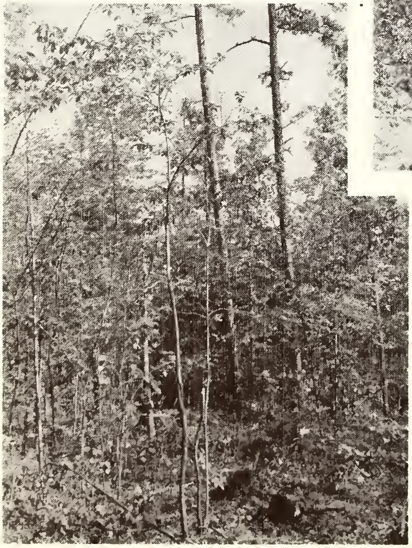


FIGURE 4. — (Left) Check plot after logging. Note that hardwood understory is relatively undisturbed.

What We Found

SHORTLEAF PINE

More than four times as many shortleaf pine seedlings became established on the plots bulldozed after logging as on the logged plots used as a check (table 1). On disked plots, there were only a little more than half as many seedlings as on bulldozed plots, though this was about twice as many as on check plots.

The total number of pine seedlings present under each treatment would be adequate to restock the cutover areas provided the seedlings were uniformly distributed and had a chance to develop properly. However, many of these pine seedlings will never survive the fierce competition that takes place in seedling and sapling stands, for they must not only compete with each other but also with the vigorous hardwood sprouts that have also become established. The number of dominant and codominant pine seedlings or those free to grow gives a better indication of the potential stocking of pine in the new stand than total numbers.

TABLE 1.—Shortleaf pine seedlings and hardwood stems by site preparation (Number per acre)

PINE REPRODUCTION[1]

Years since treatment[2]	Bulldozed	Disked	Check
1	8,700	6,100	2,250
2	13,200	7,500	3,400
4	9,250	5,300	2,150

HARDWOOD STEMS

Years since treatment[2]	Bulldozed	Disked	Check
0	1,500	3,000	6,600
4	5,200	8,900	8,600

[1] Figures are averages of pine reproduction from 6 and 15 seed trees per acre. The number of seed trees left after logging made a difference in the number of shortleaf pine seedlings present in 1957 (Dale, Martin E., Ground treatment and seed supply influence establishment of shortleaf pine reproduction, U.S. Forest Serv. Cent. States Forest Expt. Sta. Note 119, 2 pp., illus. 1958). But differences were no longer statistically significant in 1960, hence figures for 6 and 15 seed trees per acre have been averaged.

[2] Logging and site preparation were carried out in 1956.

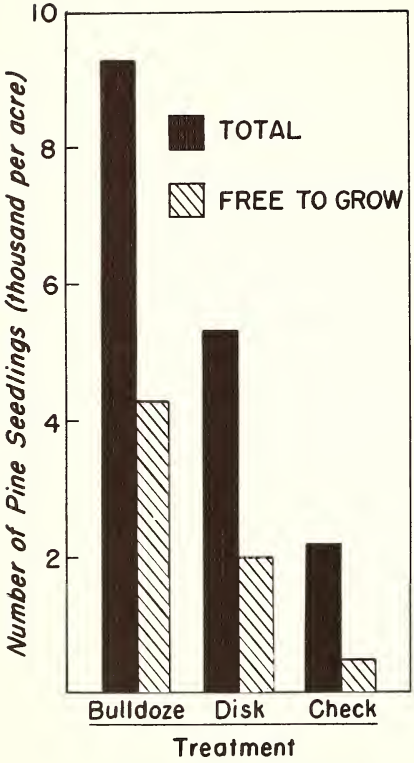


FIGURE 5. — Number of established shortleaf pine seedlings in 1960.

Almost half the pine seedlings on bulldozed plots are free to grow (fig. 5) and these are distributed fairly uniformly over the plots. Only about one-third of the pine seedlings on disked plots and one-fourth of those on check plots are free to grow. Moreover, those on disked plots are concentrated in small groups while those on check plots occur only along skid trails and on log landings.

HARDWOODS

None of the treatments eliminated the hardwoods completely. There are, however, fewer hardwoods on bulldozed plots than on either disked or check plots (table 1). This is because the bulldozer destroyed more of the original hardwoods by completely uprooting them, thus preventing them from sprouting.

Undesirable species such as red maple (*Acer rubrum* L.), sourwood (*Oxydendrum arboreum* (L.) DC.), dogwood (*Cornus florida* L.), and blackgum (*Nyssa sylvatica* Marsh.) account for 60 percent of the hardwoods on bulldozed plots, 75 percent on disked plots, and 50 percent on check plots. Remaining trees are of species that are usually desirable such as scarlet (*Quercus coccinea* Muenchh.), black (*Q. velutina* Lam.), chestnut (*Q. prinus* L.), and white (*Q. alba* L.) oak and hickory (*Carya* spp.). But few of them will develop into good-quality trees because of their sprout origin and occurrence in clumps (fig. 6).

At present, the competition from the hardwoods on bulldozed plots is not enough to seriously crowd the pine which seems adequate to provide a well-stocked stand. But hardwoods are continuing to grow with sprout vigor and release of the pine may yet be necessary in 3 to 5 years. On the other hand, the hardwood competition on disked and check plots is already serious. Stems that were cut off or only partially uprooted with the disk have sprouted profusely. Some weeding in disked plots is now necessary to release crowded pine

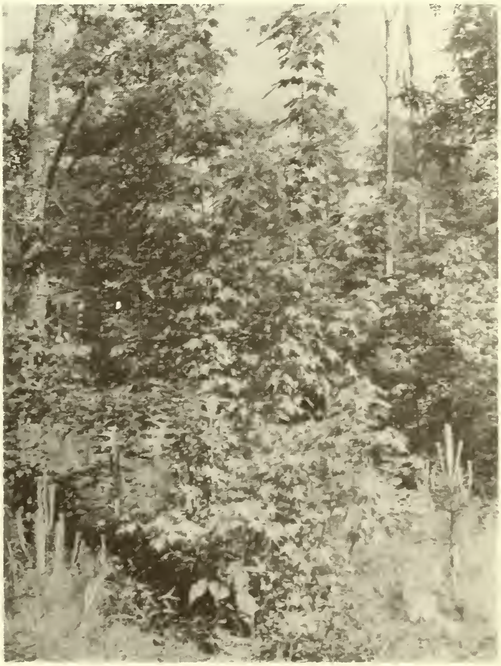


FIGURE 6. — Most of the hardwoods on the bulldozed and disked plots occur as multiple-stemmed clumps such as this.

seedlings and to keep more of them from being overtopped in the future. Very few of the original hardwoods on check plots were destroyed by the logging and when the overstory was cut the rest were released. They are increasing in size and rapidly closing over the skid trails. Very few, possibly none, of the pine will survive unless released immediately.

PLANT COVER

Despite the large number and good distribution of the natural shortleaf pine regeneration on bulldozed areas, it is difficult to predict how much restocking to pine will actually result. This is because of the large decrease in number of pines between the second and fourth years after treatment and the corresponding increase in the number and size of hardwood stems (table 1). It is well known that plant cover makes a big difference in survival and maturation of pine; the less shading and crowding that pine faces from competing vegetation, the more likely it is to survive to maturity. Because of this, cover was surveyed 3 years after logging and site preparation to get some idea how much pine would continue to survive. This survey of the vegetation also permitted some guesses on how the number of pine seedlings had already been affected by plant cover.

Ground Layer

The ground layer was considered to consist of all species of herbs, grasses, and low shrubs less than 3 feet tall. Although many species were present, only a few occurred frequently enough to be of any importance. The most abundant ones were:

Herbs
    Cinquefoil (*Potentilla* spp.)
    Goldenrod (*Solidago* spp.)
    Lespedeza (*Lespedeza* spp.)
    Loosestrife (*Lythrum* spp.)
    St. Andrewscross (*Ascyrum hypericoides* L.)
    Sunflower (*Helianthus* spp.)
    Tick-trefoil (*Desmodium* spp.)

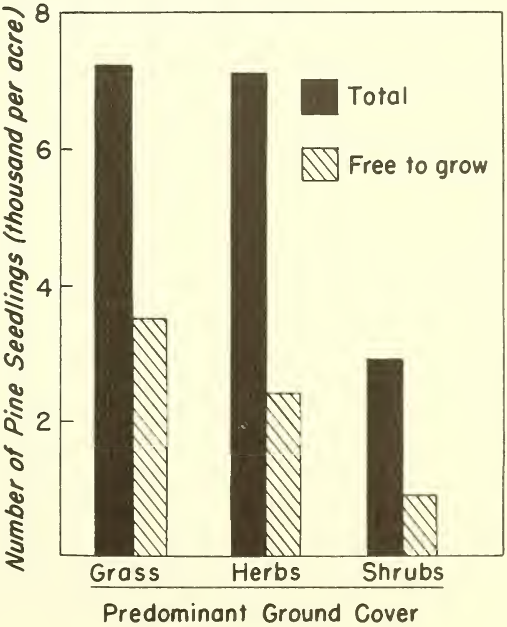
Grasses
    Panic Grass (*Panicum* spp.)
    Povertygrass (*Danthonia spicata* (L.) Beauv.)

Shrubs and vines
  Blackberry (*Rubus* spp.)
  Greenbrier (*Smilax* spp.)
  Blueberry (*Vaccinium* spp.)
  Grape (*Vitis* spp.)

Three years after cutting, vegetation within the ground layer appeared to differ according to site preparation, so an attempt was made to learn what kind of plant association was typical for each method of site preparation. On bulldozed plots, this was an association of grass and herbs; on check plots, low shrub and herbs. But on disked plots, the predominant vegetation of the ground layer differed so much from plot to plot that no particular association could be defined, although generally there were more herbs than either grass or low shrubs.

Regardless of the method of site preparation used, more shortleaf pine seedlings were free to grow where the ground layer was mostly grass than where it was either herbs or low shrubs (fig. 7). Almost four times as many free-to-grow pine seedlings were established on plots with grass as on plots with low-shrub cover and the

FIGURE 7. — Number of established pine seedlings in 1960 by predominant ground vegetation.



number on plots with mostly herbs was intermediate. Regardless of whether the vegetation in the ground layer was mostly grass, herbs, or low shrubs, the pine seedlings are now beginning to emerge above it and competition from it should diminish in the future.

Understory and High-Shrub Layers

Even though pine seedlings are beginning to rise above the ground layer, they must still compete in many places with understory and high-shrub layers. Composed entirely of shrubs and hardwood sprouts over 3 feet tall, these layers provide much greater competition than does the ground layer.

Preliminary analysis showed that both the understory and high-shrub layers had the same type of effect on the pine seedlings. Therefore, though the percent of ground covered by these layers was estimated separately, they are considered as a single layer and figures combined in the final analysis.

As expected, both the number of shortleaf pine seedlings established and the number free to grow were greatest where these layers cover the least percent of ground (fig. 8). As the area covered by understory and high shrubs increased from about 60 to 80 percent, the number of pine decreased sharply.

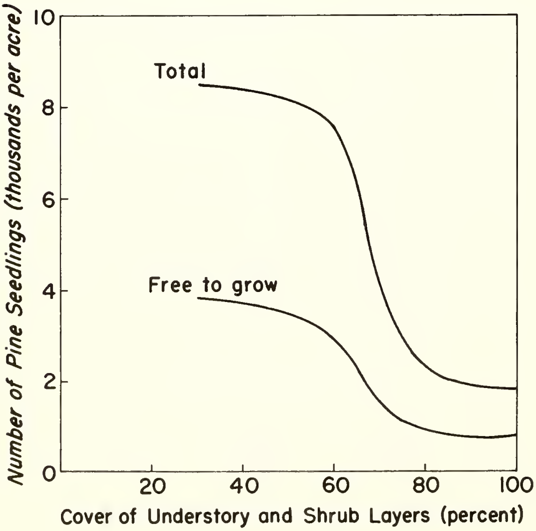
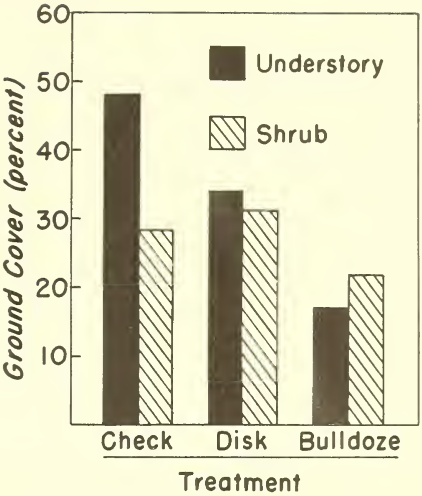


FIGURE 8. — Relation between number of pine seedlings and percent of ground area covered by the understory and shrub vegetation layers.

FIGURE 9. — Percent of the ground area covered by the understory and high shrub layers.



The percent of plot area occupied by these two layers was related to the method of scarification (fig. 9). On bulldozed plots high layers covered 30 to 60 percent of the area; thus no bulldozed plots are in the region of sharp decrease in numbers of pine. On disked plots high layers covered 40 to 90 percent of the area, with all but two plots in the region of sharp decrease. On check plots high layers covered 60 to 100 percent of the area; and on all but one plot the number of pine is already within the region of sharp decrease.

We cannot attribute the difference in pine numbers to the effect of cover alone because site preparation differed. But the decrease in pine is so pronounced where high layers cover more than 60 percent of an area that a prime objective should be to keep the percent of an area they occupy below 50 to 60 percent. Sometimes there appears to be enough shortleaf pine to form an adequate stand even where the understory hardwoods and tall shrubs cover more than 60 percent of an area. But crowding and shading will probably get worse, and more and more of these pines will be lost unless they are freed by killing the hardwoods. The physical job of keeping them free is much greater and more expensive than where high layers occupy less than 60 percent of an area.

Summary

A study established in 1956 on cutover areas in mature oak-pine stands on the Cumberland Plateau in Kentucky shows 6 seed trees per acre in good seed-production years such as 1956 and 1957 will produce enough seed to regenerate shortleaf pine. Of the methods of scarification tried, bulldozing resulted in 9,250 established shortleaf pine seedlings per acre 4 years later, disking in 5,300, and logging alone used as a check in 2,150. Of the total number of pine seedlings on each treatment, the number free to grow was 4,300 on bulldozed plots, 2,000 on disked plots, and 500 on check plots. Competition of hardwood sprouts as measured by the percent of ground they cover is least in bulldozed plots, greatest in check plots, with disked plots falling in between. Release is necessary in disked and check plots in order to keep pine as a major component of the new stand.

Agriculture — Forest Service — Columbus, Ohio

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